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INTERIM AIR QUALITY MODEL GUIDELINE

for comment only

Alberta
ENVIRONMENT

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The "Interim Air Quality Model Guideline" is a FINAL DRAFT document. Comments on the document are welcome until **September 30th, 2000.**

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PREFACE

The Alberta Environment (AENV) Air Quality Modelling Guideline (Guideline) is intended for operations and proposed operations that require an Environmental Protection and Enhancement Act (EPEA) approval or that operate under a Code of Practice for emissions to the atmosphere.

Alberta Environment has developed the Guideline to ensure consistency in the use of plume dispersion models for regulatory applications in Alberta. The practices recommended within this guideline are a means to ensure that these objectives are met.

The Guideline outlines Alberta Environment's dispersion modelling requirements and methods. Although some specific information on models is given, the user should refer to user guides and reference materials for the model of interest for further information on dispersion modelling. The Guideline will be reviewed regularly to ensure that the best available tools are being used to predict air quality.

Additional information relevant to dispersion models can be located at these web pages:

- http://www.gov.ab.ca/env/air/
- http://www.gov.ab.ca/env/air/airqual/airmodelling.html
- http://www.gov.ab.ca/env/air/airqual/metdata.html
- http://www.epa.gov/scram001
- http://www.cmc.ec.gc.ca

It should be noted that this draft of the Air Quality Modelling Guideline is only for public consultation and the draft version of the Air Quality Modelling Guideline dated July 1999 remains in effect.

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1 INTRODUCTION

This guideline provides detailed guidance on suitable methods and approaches that should be used to assess air quality from emission sources. It sets out

- the statutory authority,
- an overview of the approach,
- guidance on appropriate technical methods, and
- the information required to demonstrate that a source meets the Alberta Ambient Air Quality Guidelines (AAAQG).

It is not intended to provide a technical description of the theory behind dispersion modelling—such information is widely available in other published documents, and references are provided within the text.

Detailed advice on the types and uses of dispersion models is provided in Sections 2 to 4. Section 5 provides guidance on the application of regulatory models, describing individual models and their intended uses. Section 6 gives internet addresses for a variety of modelling resources. Appendix A lists the contents of screening assessments expected by Alberta Environment. Appendix B lists the expected contents of refined and advanced assessments

1.1 Purpose of the Air Quality Modelling Guideline

Alberta Environment (AENV) has developed the Air Quality Modelling Guideline to ensure consistency in the use of plume dispersion models in air quality assessments. The objectives are to

- provide for uniform benchmarking,
- provide a structured approach to selection and application of models,
- ensure that there is a sound scientific basis for the use of alternatives, and
- detail the required content of assessments submitted to the department.

The Guideline addresses only primary substances directly emitted from a source. Some substances are formed in the atmosphere as a result of the interaction of these primary substances with substances from either natural or industrial sources. These are known as secondary substances (e.g., PM2.5). Concentrations of secondary substances must be estimated by other means acceptable to AENV.

1.2 Statutory Authority

This guideline is issued by Alberta Environment, under Part 1, 14 (4), the Environmental Protection and Enhancement Act 1992 (EPEA).

This guideline should be read in conjunction with the Alberta Ambient Air Quality Guidelines and the Air Monitoring Directive.

1.3 Air Quality Models

Alberta Environment works with Albertans to protect and enhance the quality of the air through a regulatory management approach that includes

- air quality models,
- ambient air quality guidelines,
- atmospheric emission inventories,
- source emission standards,
- approvals,
- environmental reporting,
- ambient air quality monitoring,
- source emission monitoring,
- inspections/abatement, and enforcement, and
- research.

Information from emission inventories and source controls are utilized in air quality modelling to relate the resulting ambient air quality to the ambient air quality guidelines. Ambient monitoring determines the actual air quality resulting from the emissions.

The purpose of a dispersion model is to provide a means of calculating ambient ground-level concentrations of an emitted substance given information about the emissions and the nature of the atmosphere. The amount released can be determined from knowledge of the industrial process or actual measurements. However, predictive compliance with an ambient air quality guideline is determined by the concentration of the substance at ground level. Air quality guidelines refer to concentration in the ambient air, not in the emission source. In order to assess whether an emission meets the ambient air guideline it is necessary to determine the ground-level concentrations that may arise at various distances from the source. This is the function of a dispersion model.

A dispersion model is a set of mathematical relationships or physical models, based on scientific principles, that relate emission rates of an air contaminant to the resulting ambient concentrations. Model predictions are useful in a wide variety of air quality decisions, including determining appropriateness of facility location, monitoring-network design, and stack design. Models also provide information on the areas most influenced by emissions from a source, the contribution of weather to observed trends, and the air quality expected under various scenarios. Dispersion modelling requires knowledge of emission rates and the local meteorology and topography.

1.4 Levels of Modelling

The choice of dispersion model depends on a number of factors. There is a wide range of models available, and it is important that the user selects the model that fits the demands of the task. Generally, there are three levels of assessment:

1. Screening assessment is utilized to determine a specific event or the likelihood of a specific event. (e.g., to predict the worst-case concentration.)

2. Refined assessment, because of its higher level of sophistication, more closely estimates actual air quality impacts.

3. Advanced assessment treats specific dispersion processes in greater detail. It potentially gives more accurate results but requires more input data. The user must be careful to ascertain whether the selected dispersion model is being applied to a situation for which the model was designed.

for comment only

2 MODELLING PROTOCOL

A dispersion model is a series of equations describing the relationships between the concentration of a pollutant in the atmosphere arising at a chosen location, the release rate, and factors affecting the dispersion and dilution in the atmosphere. The model requires information on the emission characteristics (see Section 3.1) and the local meteorology (see Section 3.2). Modelling can also be used to predict future scenarios, short-term episodes, and long-term trends.

Nearby buildings and complex topography can both have significant effects upon the dispersion characteristics of a plume. Buildings may cause a plume to come to ground much closer to the stack than otherwise expected, causing significantly higher pollutant concentrations. Plumes can impact directly on hillsides under certain meteorological conditions, or valleys may trap emissions during low-level inversions.

A hierarchy of commonly used dispersion models has been established, categorizing the models according to how they might be used within the assessment process. For example, 'screening' models are used as a benchmark or an initial step of the review, and refined models for more detailed analysis. Advanced models may be needed, depending upon the type of source(s) being studied and the complexity of the situation.

2.1 Modelling Decisions

All proposed emissions to the atmosphere that are subject to an EPEA approval from AENV are subject to the appropriate modelling assessment. The flow chart for modelling categories is shown in Figure 1.

For other types of facilities, the dispersion models outlined in this guideline or equivalent ones developed in consultation with AENV may be used to demonstrate compliance with the AAAQG.

When a renewal is required for existing facilities, a screening assessment using the current models must be submitted for benchmarking. Further modelling may be required at the discretion of the Director, if

- the monitoring data show exceedances,
- there are many other emission sources in the area,
- the area contains sensitive receptors, or
- changes in emissions are expected at the facility.

The flow chart is shown in Figure 2.

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Figure 1: **Flow chart indicating situations in which different categories of dispersion models might be used.**

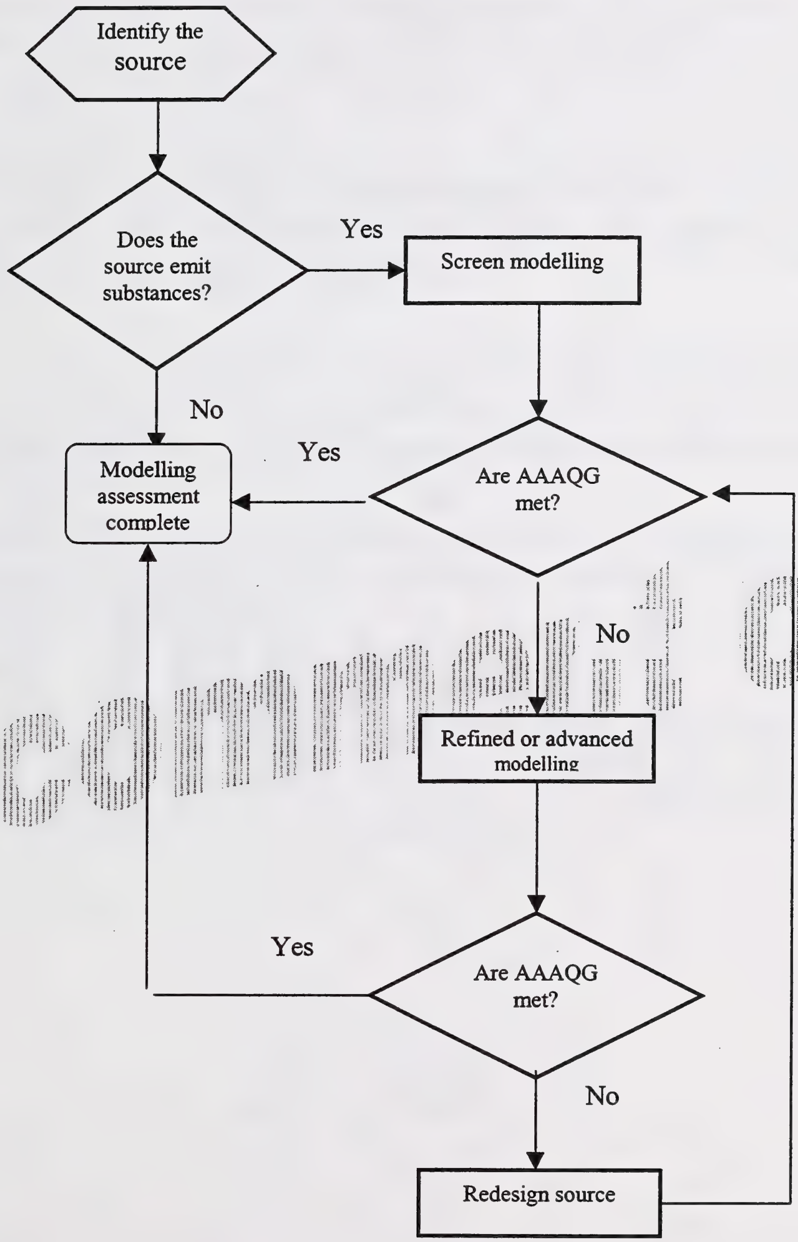

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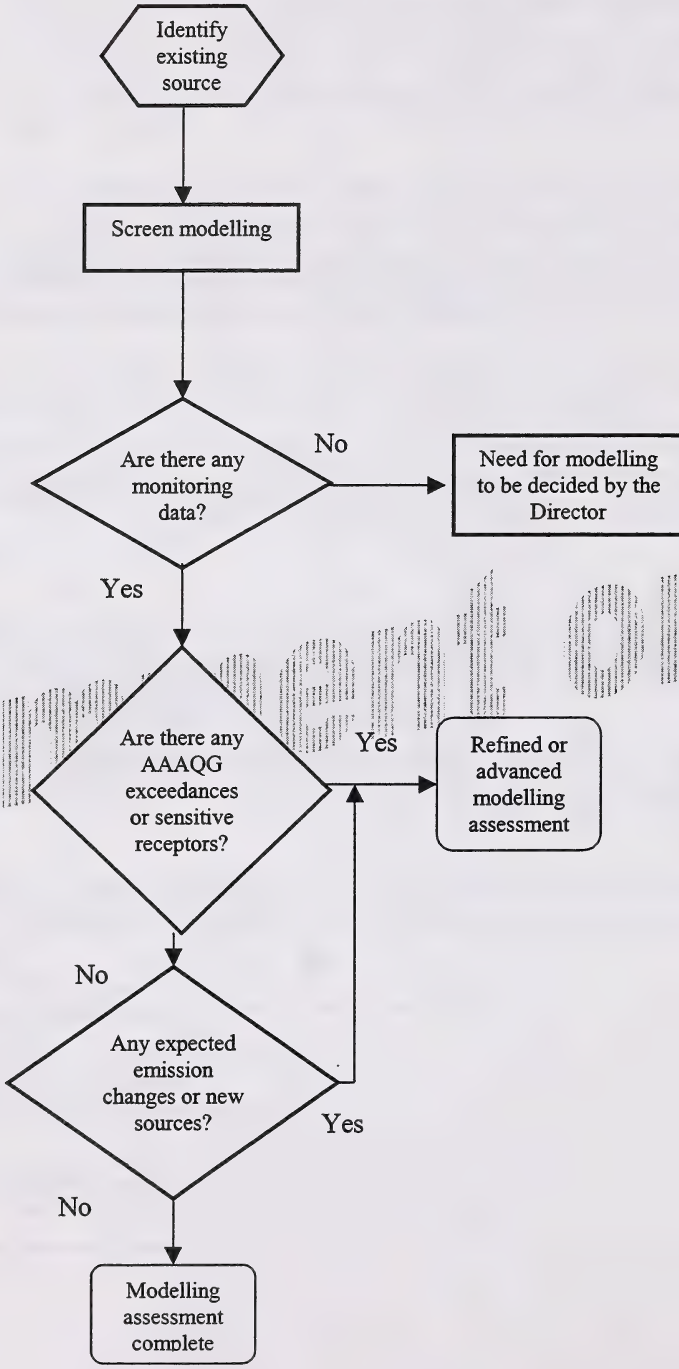
Figure 2: Flow chart indicating dispersion modelling situations for approval of renewal for existing facility.



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2.2 Screening Models

The first tier of evaluation for single- or multiple-source impact employs a screening method using SCREEN3 or ISC3 with regional screening data (See Section 3.2.2). The screening model results serve as benchmarks for each type of source and for comparison against other sources.

In order to simplify the running of a computer model, some models, such as SCREEN3, already have preset meteorological conditions included within them. There is then no need to consider local meteorology. The models will calculate worst-case concentrations and may provide the user with information on the meteorological conditions that gave rise to these concentrations.

Screening models, such as SCREEN3, quickly give an initial impression of the highest concentrations that are likely to occur. Generally, however, they can only treat one source at a time. If multiple sources are not further than 500 m apart or at different elevations, the sources can be modelled separately, and the maximums (regardless of location) should be totalled.

If concentrations, after adding the background, are below the air quality guidelines, it is usually unnecessary to undertake further modelling (see Section 4.0). Figure 3 shows the flow chart for the screening level.

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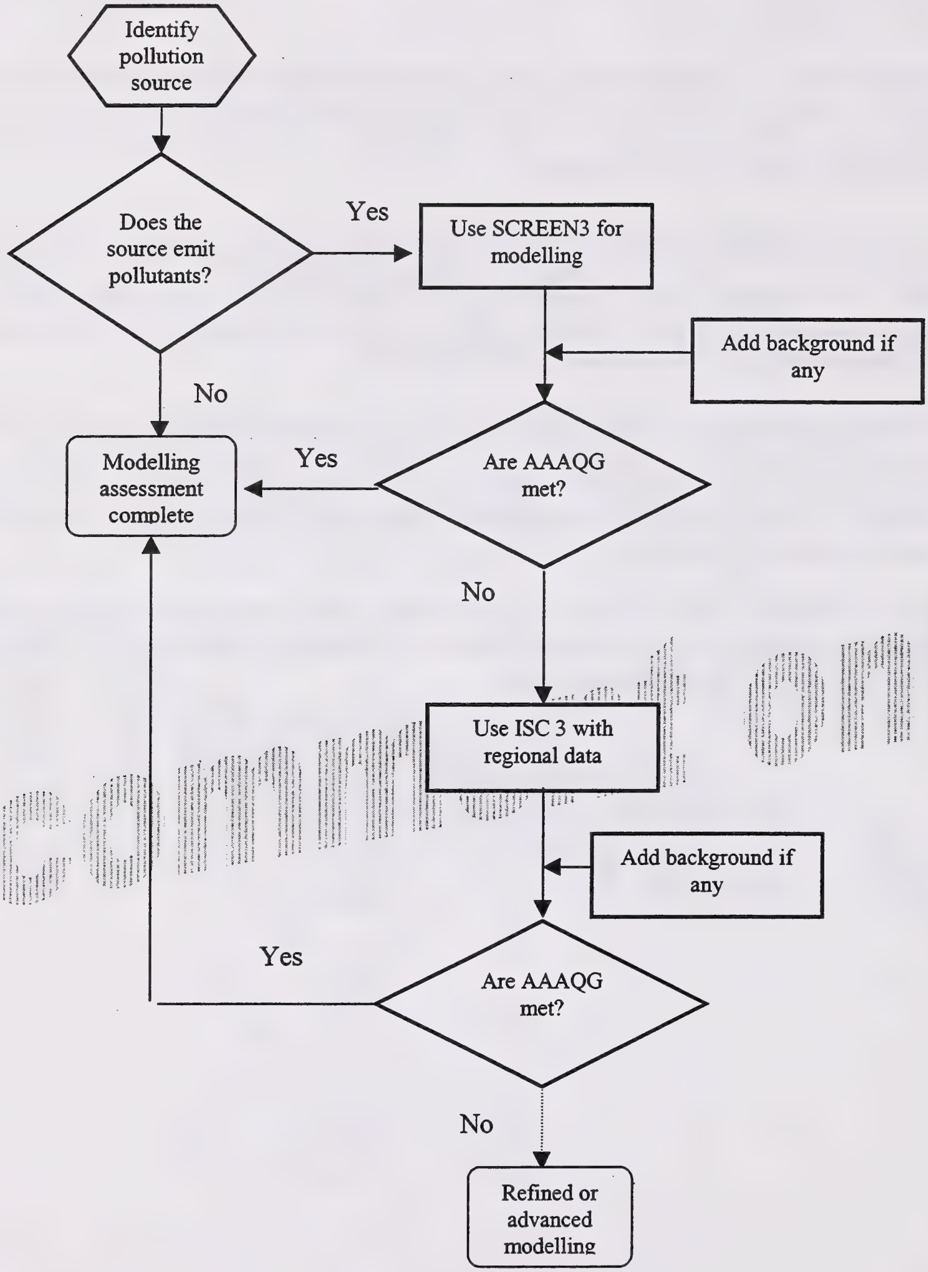
Figure 3: Flow chart for screen modelling tier.



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2.3 Refined Models

If the screening assessment has predicted exceedances of AAAQG, the second tier is required.

The second tier, to address the impacts of single or multiple sources, involves a refined assessment. Refined assessments are required if any of the following conditions apply:

- The source is in an airshed where there are other emissions such as an industrial park, industrial region, or urban area.
- The area is environmentally sensitive (e.g., a national park).
- Public concerns need to be addressed.

Brief descriptions of the regulatory refined models are presented in Section 5 (See Section 4 for output interpretation).

2.4 Advanced Models

For an advanced assessment using an alternative or modified model, details should be verified with AENV prior to submission.

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3 INPUT DATA

All dispersion models require some form of input data that describe how much pollutant material is being released, details on how the pollutant is being released, and the environment into which the release occurs. It is also necessary to define the locations at which the impact of the emissions is to be predicted; these are termed 'receptor' locations.

The accuracy of the data input to the model has a significant effect on the accuracy of the predicted concentrations. Where the model assumes that the emissions are not chemically transformed in the atmosphere, (except for CALPUFF), the predicted concentration is directly proportional to the emission rate, i.e., if the emission rate is doubled, the predicted concentration also doubles. This relationship follows regardless of how simple or sophisticated the dispersion model is. The collation of accurate emissions data is therefore extremely important.

3.1 Source Input Data

Different source types are defined as follows:

- ***Point sources*** are localized sources such as stacks or flares. The simpler models can treat only one point source at a time, though more sophisticated programs can include a very large number of stacks simultaneously.
- ***Line sources*** are sources were emissions are in linear form such as roads.
- ***Area sources*** are clusters of point or line sources (e.g., fugitive emissions from industrial processes having numerous vents).
- ***Volume sources*** are three-dimensional sources such as area sources distributed with a vertical depth, for example, emissions from lagoons.

The selection of emission rates for input to the model depends on the type of model and the purpose for which the model is being used. When using models for stack design the approved hourly maximum emission rate should be used. However, when the model is used to predict annual average concentrations, typical emission rates will be adequate for the purpose.

For areas with multiple facilities, the emissions of all of the other sources in the airshed should be included. Stack parameters from existing facilities can be determined from approval limits, Continuous Emission Monitoring Systems (CEMS), or manual stack surveys. In some cases it is not practical to conduct manual stack surveys, so emission factor estimates from published sources can be used (manufacturer specifications or AP-42) (U.S. EPA, 1995a).

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If sources operate only during specified hours, the modelling analysis can be restricted to the hours of operation. If this type of assessment is selected, special approval conditions may apply to restrict the operation to the time periods that were modelled.

Continuous flares should always be designed in conformance with the most current guidelines and standards recommended by Alberta Environment or the Alberta Energy and Utilities Board. Emergency flares should be modelled and assessed using guidance from the most current document, by AENV 1999, entitled “Emergency/Process Upset Flaring Management: Modelling Guidance” (AENV, 1999a).

If the stack emissions contain large particles (greater than about 40 μm in diameter), information relating to the particle size distribution may also be required.

3.2 Meteorological Data

3.2.1 Screening meteorological data set

The screening meteorological data are built into some screening models. However, for multiple-source situations the screening models cannot be used.

Since most screening models handle only a single source at a time, wind direction is not a factor in determining worst-case conditions in flat terrain. For multiple-source combinations, use of a variety of wind directions is important.

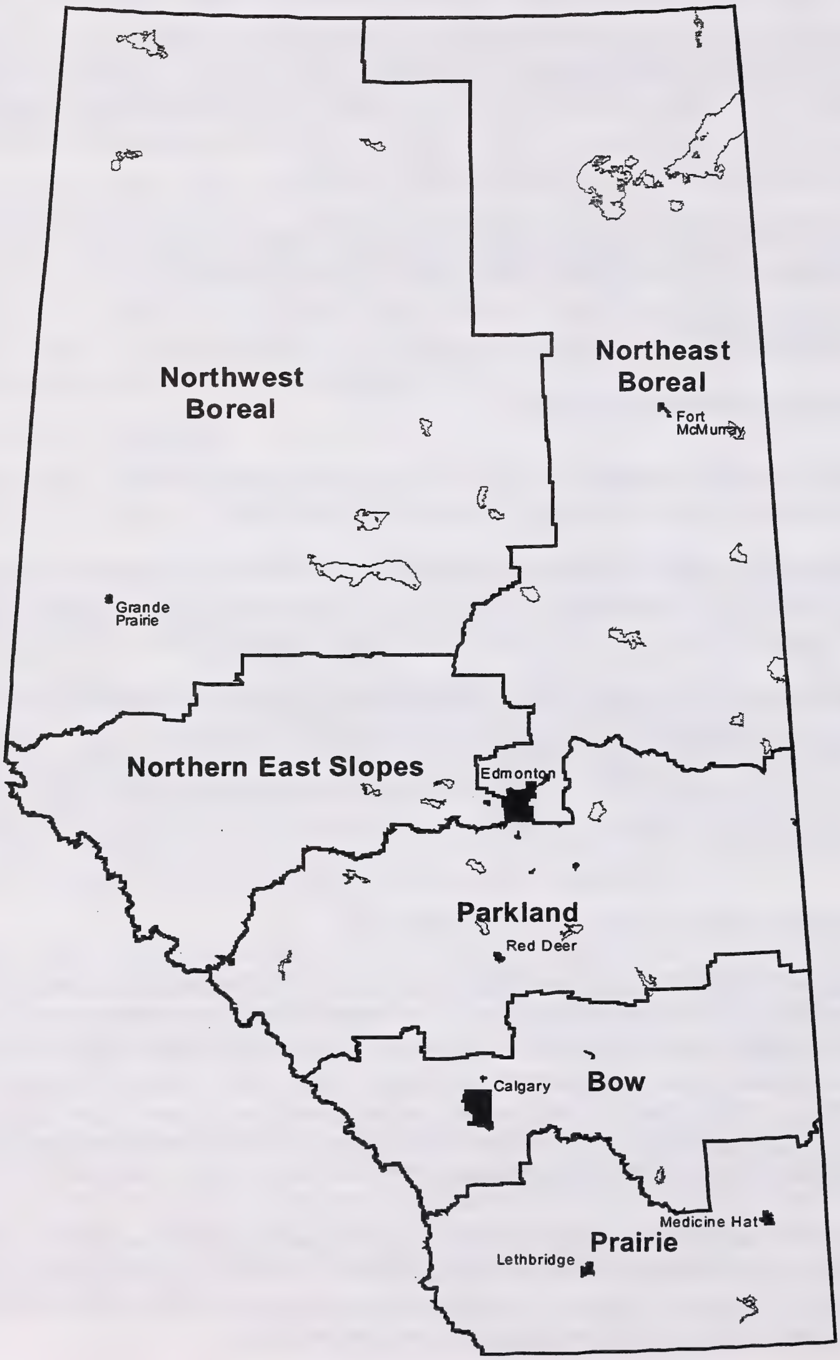
AENV has developed regional screening meteorological data for the six regions (see Figure 4), which can be used for screening purposes only. The data, in ISC3 format, are available on the AENV web page, as noted in Section 6.1. Supporting documentation for the six regional data sets can be found in Comparison of Meteorology Elements in the Alberta Environment Regional Screening Dispersion Modelling Data Sets (AENV, 1999).

3.2.2 Refined and advanced meteorological data sets

For refined assessments, actual near-site data are used. The representativeness of the actual data depends on the proximity of the meteorological monitoring site to the activity, the complexity of the terrain, the exposure of the instruments, the time of data collection, and the data recording method (Hoffnagle et al., 1981; Nappo et al., 1981; Walmsley & Bagg, 1978). Data for refined modelling must be shown to be temporally and spatially representative of the site of the facility. One of the following meteorological data sets should be used in a refined assessment:

- A minimum of 1 year of site-specific meteorology. Site-specific data must be related to the longer term (seasonal or annual) by statistical methods. Relating site-specific meteorology to data from climate or meteorological stations having longer collection periods ensures that site data are temporally representative.

Figure 4: Map showing regions of Alberta.



- The most recent 5 years of meteorological data, readily available from a nearby airport station, must be utilized. When using airport meteorological data in refined modelling, studies have shown that at least 5 years of data must be used to obtain stable distributions (U.S. EPA, 1998).

These data can be purchased from Environment Canada's Meteorological Service.

Missing meteorological data must be processed prior to being utilized in a model. There are numerous methods of processing missing data. Generally:

- Consecutive years of data should be used.
- A data set should not be used if fewer than 90% of the annual data are available.
- When missing data values arise, they should be handled in one of the ways listed below, in the following order of preference (U.S. EPA, 1987):

    1. If there are other on-site data, such as measurements at another height, they may be used when the primary data are missing and corrections based on established vertical profiles should be made. Site-specific vertical profiles based on historical on-site data may also be appropriate to use after consultation with AENV.

    2. If there are only one or two missing hours, linear interpolation of missing data may be acceptable, however, caution should be used when the missing hour(s) occur(s) during day/night transition periods.

    3. If representative off-site data exist, they may by used. In many cases, this approach is acceptable for cloud cover, ceiling height, mixing height, and temperature.

- Consult with AENV regarding substitution of data for longer periods, or if insufficient data is available. For these cases, shorter periods or appropriate substitution of data can be used with approval from AENV.

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3.3 Surface Roughness

Surface roughness determines the degree of ground turbulence caused by the passage of winds across surface structures. The following method is to be used for selecting the rural or urban surface roughness category.

Classify the land use within a 3-km radius of the source. If more than 50% of the land use falls within the following categories—heavy or light industrial, commercial, and compact residential (two-story dwellings, limited lawn sizes)—it is considered to be urban. Otherwise, use the rural coefficients by selecting rural roughness, except for forests, which are treated as urban locations.

3.4 Local Buildings

To take account of local building effects, models generally require information related to the dimensions and location of the structures with respect to the stack. If the stack is located on the top of a building, or adjacent to a tall building, it may be necessary to consider the size of these buildings. As a general guide, building downwash problems may occur if the height of the top of the stack is less than 2 ½ times the height of the building upon which it sits. It may be necessary to consider adjacent buildings if they are within a distance of 5 times the lesser of the width or peak height from the stack (5L). This distance is commonly referred to as the building's *region of influence*. If the source is located near more than one building, assess each building and stack configuration separately. If a building's projected width is used to determine 5L, determine the *apparent width* of the building. The apparent width is the width as seen from the source looking towards either the wind direction or the direction of interest. For example, the ISCST3 model requires the apparent building widths (and also heights) for every 10 degrees of azimuth around each source.

To account for downwash, the SCREEN model requires the height of the building or structure and the respective maximum and minimum horizontal dimensions. Generally, include the building with dimensions that result in the greatest stack height for that source, to evaluate the greatest downwash effects. Be aware that when screening tanks, the tank diameter should not be used. The SCREEN model uses the square root of the sum of the squares of the width and length of a structure in order to calculate the projected width. Because most tanks are cylindrical, the projected width is constant for all flow vectors. However, using the actual tank diameter for both width and length will result in a projected width that is too large. Therefore, when screening tanks, the model user should divide the diameter of the tank by the square root of 2.

Due to the complexity of building downwash guidance, the U.S. EPA has developed a computer program for calculating downwash parameters for use with the ISC models. This program is called the BPIP (U.S. EPA, 1993a), and it is available from the U.S. EPA SCRAM web site. Use the most current version of the BPIP to determine downwash parameters for use with the ISC models. Building downwash should not be analyzed for area or volume sources.

3.5 Selecting Receptor Grid

The user needs to define the locations at which ground-level concentrations are to be predicted. In selecting receptor locations, it is general practice to identify the nearest, sensitive locations to the stack, such as residential housing, hospitals, etc. A careful selection of receptor points should be made so that the maximum ground-level concentration is found.

Most models allow the selection of a polar or a Cartesian receptor grid. A polar grid, consisting of a number of radials, is most useful when only one source is present. A Cartesian grid (can be regularly or irregularly spaced) is better for multiple-source facilities. Since the number of allowed receptors is limited, they should be more densely located where maximum impacts are expected. To ensure the maximum concentrations are obtained, the model should be run with the following set of receptors:

- 20-m receptor spacing in the general area of maximum impact and the property boundary,
- 50-m receptor spacing within 0.5 km from the source,
- 250-m receptor spacing within 2 km from the sources of interest,
- 500-m spacing within 5 km from the sources of interest,
- 1000-m spacing beyond 5 km.

It is best to run the model twice, first with the coarse grid to determine the areas of impact, and then with the finer grid to obtain the maximums.

In areas with many industrial sources, or for large buoyant sources (100-m tall stacks, high exit temperature), a larger 250-m grid, and a coarse grid out to a distance of 20 km may be necessary to find the area of maximum impacts. In some cases, an even larger grid may be necessary.

The model domain for any assessment should not exceed the limitations of the model. If it is necessary to model at points beyond the model limitations, the results should be interpreted with extreme caution.

for comment only

3.6 Terrain Situation

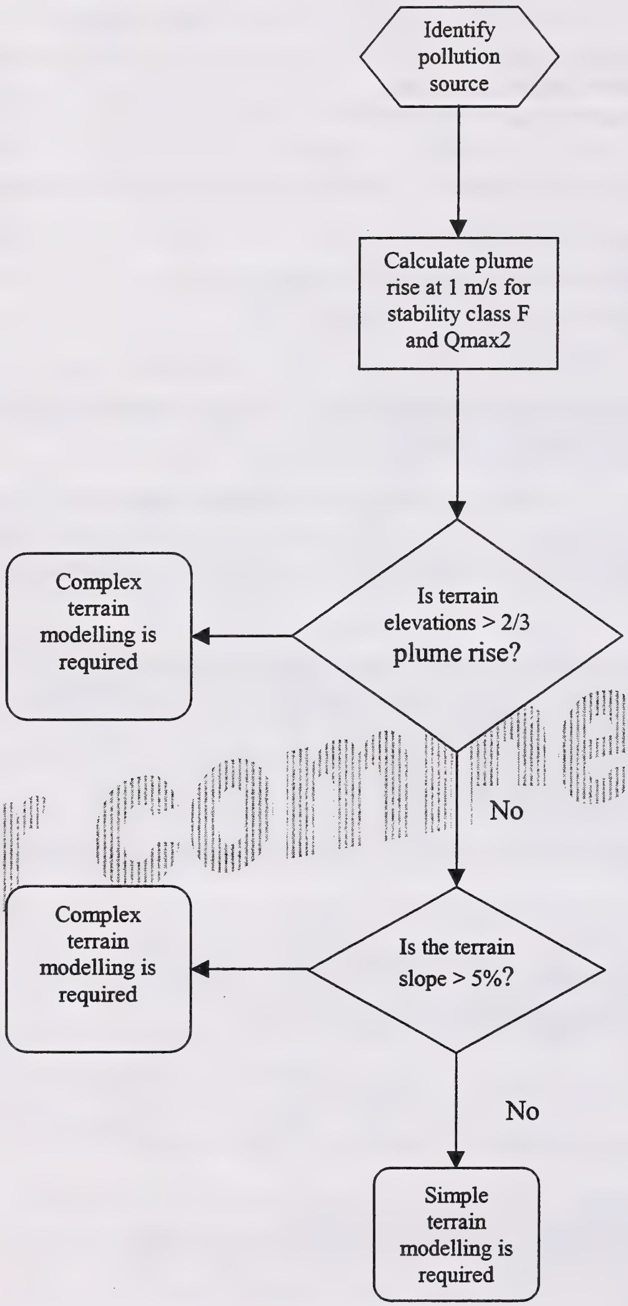
The terrain in the vicinity of a source can fall into two main categories as defined by AENV:

- Simple terrain (parallel air flow) - terrain with elevation that does not exceed 2/3 of plume rise at stability class F with wind speed 1 m/s and flow rate equals to Qmax/2.
- Complex terrain - terrain with elevation above parallel air flow.

In general, the larger the source, the greater the distance to which consideration of possible impacts of terrain elevations must extend. When modelling a facility, terrain in the local airshed surrounding the source must be considered if (see Figure 5):

- there is any complex terrain within the modelling domain, or
- terrain elevation rises more than 50 m per 1000 m distance from the source.

Figure 5: Flow chart for simple and complex terrain determination



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4 OUTPUT INTERPRETATION

The input to dispersion models consists essentially of emissions and meteorological data. The output from dispersion models consists of concentration values. Predicted concentrations are expressed as micrograms per cubic metre ($\mu g/m^3$) of air. Concentrations of gases may also be expressed as the ratio of the volume of the substance to the volume of air. In this case, concentrations are expressed as parts per million (ppm) or parts per billion (ppb). The following equation is recommended for converting the concentrations in $\mu g/m^3$ to ppm:

$$[ppm] * 40.8862 * \text{molecular weight} = [\mu g/m^3] \qquad (4.1)$$

4.1 Meeting Alberta Ambient Air Quality Guidelines

The concentration of a pollutant will vary from second to second because of turbulence in the atmosphere. For practical use, concentrations are expressed as averages over specified time periods. Ambient air quality guidelines are usually stated for 1-hour averages, 24-hour averages, and annual arithmetic means.

For a given emission rate, predicted concentrations at ground level can be high due to extreme, rare, and transient meteorological conditions. These maximum ground-level concentrations are considered outliers and should not be used as the basis for selecting stack height. Therefore, the highest eight 1-hour predicted average concentrations in each single year should be disregarded. This approach is to be followed only for screening modelling using a regional data set and for refined and advanced modelling.

If Alberta Ambient Air Quality Guidelines do not specify a value for the substance, the lesser of Ontario point-of-impingement or Texas Ambient Air Quality Guidelines concentrations should be used. If neither Ontario nor Texas has a value for the substance of interest, a risk assessment should be conducted. Contact AENV to work out details.

4.2 Background Concentrations

Background air quality includes chemical concentrations due to natural sources, nearby sources, and unidentified, possibly distant sources. When conducting a screening or refined assessment, the background value for the same substance must be added to the predicted value before a comparison to the ambient air quality guideline is made. Assessing the effects of the background component becomes more complex when the number of exceedances of a short-term concentration standard (l-hour, 24-hour averages) is being considered. In this case, ground sources and elevated sources must be treated differently.

For example, the highest concentrations from ground sources will likely occur under calm and stable conditions during the winter. In the case of an elevated source, the weather conditions that result in the highest concentrations are convective or neutral conditions. Therefore, the addition of the maximum background concentrations to model predictions should be made under similar weather conditions.

Consider, as an example, a situation where the highest 1-hour concentration of NO_X predicted to arise from a stack is 230 μg/m^3. During calm, stable conditions, the impact of the stack emissions is likely to be very low. The highest 1-hour ground-level NO_2 concentration is estimated by adding the calculated concentration to the annual average NO_X background. For example, 76 μg/m^3, the estimated ground-level concentration would be 76 + 230 = 306 μg/m^3 NO_X.

Air quality data collected in the vicinity of the proposed source may be used as background values. The following method should be used to determine a background concentration:

- Generally, at least one year of monitoring data is necessary, as there are usually significant seasonal differences in ambient concentrations. This can be due to atmospheric differences or because of the seasonal nature of some operations.
- All monitoring data should be subjected to validation and quality control to ensure its accuracy (Nelson et al., 1980).

4.3 Relationship between NO_X and NO_2

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Of the several species of nitrogen oxides, only NO_2 is specified in the Alberta Ambient Air Quality Guidelines. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume must be given. The recommended methods, described below, are implemented using a tiered approach as shown in Figure 6:

1. Total Conversion Method

   In this conservative screening approach, the emission rate of all NO_X species is used in the dispersion model to predict ground-level concentrations of total NO_X. These levels of NO_X are assumed to exist as 100% NO_2, and are directly compared to the AAAQG for NO_2. If the AAAQG are met, the second tier is not necessary.

2. Ambient Ratio Method

If there is at least one year of monitoring data available for NO_X and NO_2 within the airshed, an empirical NO_X /NO_2 relationship can be derived and used as an alternative to the ozone limiting method. AENV must approve this approach prior to its use.

3. Ozone Limiting Method (OLM) (Cole & Summerhays, 1979)

If no on-site ozone data are available, use the following ozone data based on ambient air quality monitoring data in Alberta from 1986 to 1998 (Alberta Environmental Protection 1986 – 1998; CASA, 1999), and the results of the Total Conversion Method must also be presented to the reviewer.

Table 1: AENV recommended ozone levels

	Urban	Rural
1-hour average	0.05	0.05
24-hour average	0.035	0.040
Annual average	0.020	0.035

for comment only

Using this measurement as a conservative assumption in the ozone limiting method produces the following:

Use the following equation with $[O_3] = 0.050$ ppm

$$\text{If } [O_3] > 0.9*[NO_X] \text{ then } [NO_2] = [NO_X] \quad (4.2)$$

$$\text{otherwise } [NO_2] = [O_3] + 0.1*[NO_X]$$

All concentrations in the previous equations are in ppm. The predicted NO_X concentrations are calculated as equivalent NO_2.

According to Equation 4.2, if the ozone concentration is greater than 90% of the predicted NO_X concentrations, all the NO_X is assumed to be converted to NO_2. The OLM is based on the assumption that approximately 10% of the NO_X emissions are generated as NO_2. The majority of the emission is in the form of NO, which reacts with ambient levels of ozone to form additional NO_2. Alternatively, if hourly ozone data are available, they can be utilized in conjunction with the hourly predictions to determine concentrations of NO_2.

If the period of interest is for the 24-hour or annual guideline, the model user has two options:

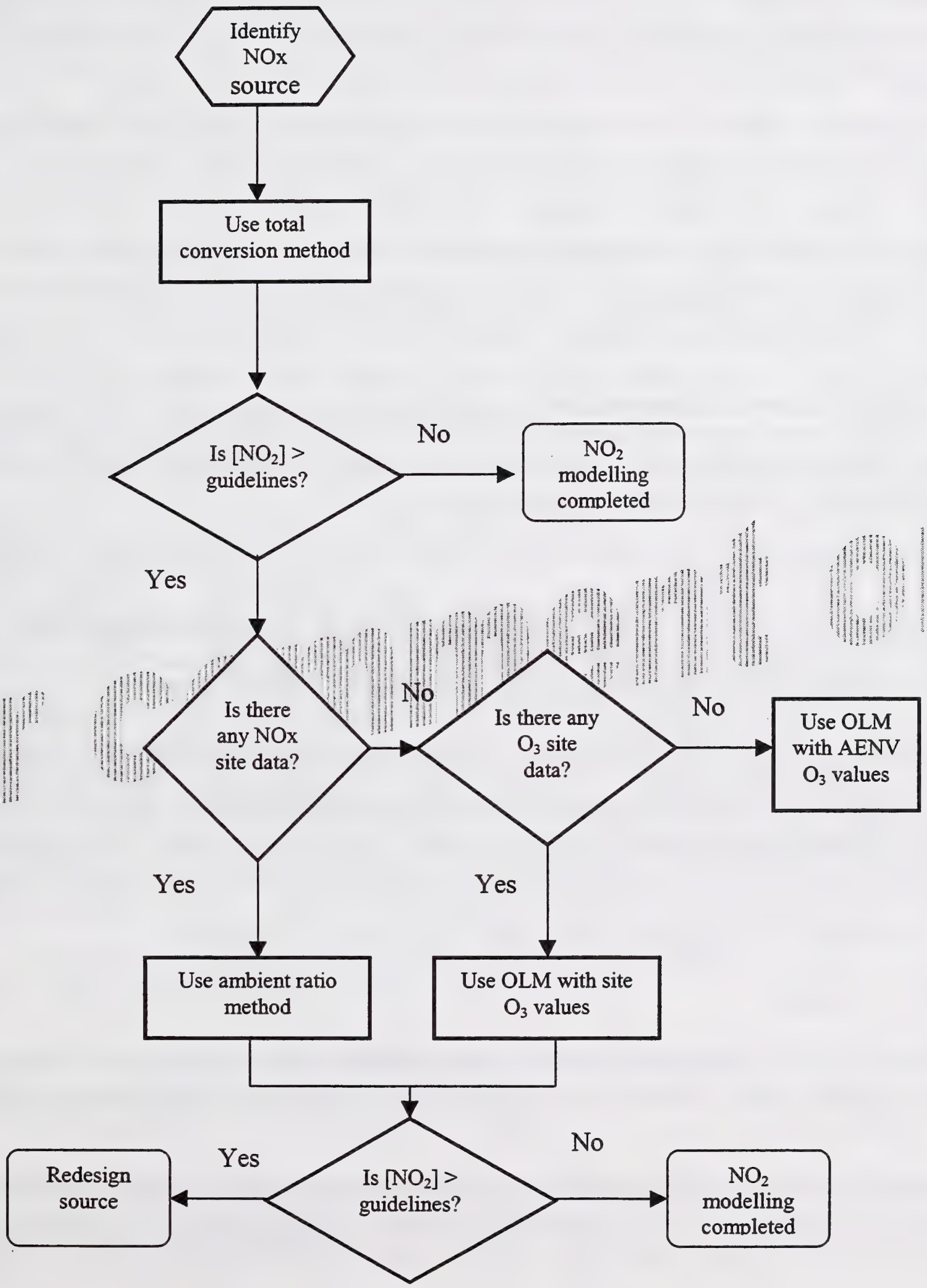
- The hourly predictions at each location can be ozone limited, and the averages could be used to determine the maximum 24-hour and annual concentrations.
- The 24-hour or annual concentration can be determined as direct output and the following O_3 concentrations can be utilized:

$$[O_3] = 0.045 \text{ ppm for 24-hour}$$
$$[O_3] = 0.025 \text{ ppm for annual}$$

If the ambient ratio method is selected as the conversion method, both the maximum 100% conversion, and the maximum ozone-limited concentrations must be presented.

for comment only

Figure 6: Flow chart indicating the relationship between NO_X and NO_2



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5 REGULATORY MODELS

A tiered approach will save both time and money, as the aim is to progressively reduce uncertainty by moving from simple and cautious models to complex and more reliable ones, as circumstances warrant. One screening model and five refined models are recommended by AENV.

All the regulatory models are short-range. That means that only air quality within about 25 km of the source is predicted reliably, except for CALPUFF, which can be used up to 200 km.

The user of a model should be able to justify the choice of any particular model and demonstrate its 'fitness for purpose'. If a simple screening model shows that emissions from a certain process can result in concentrations that are well below the air quality objective, including background levels, more detailed modelling should not normally be necessary. Refined or advanced models need to be used if the screening predictions of ambient ground concentrations exceed the relevant air quality guidelines. The choice of model is dependent on the quantity and quality of the available input data. If the screening review indicates that more refined modelling is required, more accurate meteorological and emission data must be used.

5.1 Screening Models

- **SCREEN3** This U.S. EPA, PC-based model uses worst-case meteorological data. It can model a single point, area, or volume source, and can take account of building wake effects. It has a limited ability to treat terrain above stack height.

- **Industrial Source Complex (ISCST3, ISC3-PRIME and ISC-OLM) with regional screen meteorological data** - This is a U.S. EPA multi-source Gaussian model capable of predicting both long-term (annual mean) and short-term (down to 1 -hour mean) concentrations arising from point, area, and volume sources. Gravitational settling of particles can be accounted for using a dry deposition algorithm; wet deposition and depletion due to rainfall can also be treated. Effects of buildings can be considered. The model has urban and rural dispersion coefficients.

for comment only

5.2 Refined Models

- **Industrial Source Complex (ISCST3, ISC3-PRIME and ISC-OLM) with refined meteorological data** – same as above but using more refined meteorological data (see Section 3.2.2).

- **AERMOD** - This is the new-generation U.S. air quality modelling system. It contains improved algorithms for convective and stable boundary layers, for computing vertical profiles of wind, turbulence, and temperature, and for the treatment of all

types of terrain. It was developed by the U.S. Environmental Protection Agency, in collaboration with the American Meteorological Society.

- **Rough Terrain Diffusion Model (RTDM)** This is a U.S. EPA Gaussian model capable of predicting short-term concentrations arising from point sources in complex terrain. It calculates 1-hour averages only; building wake effects cannot be modelled; only rural dispersion coefficients are available. RTDM requires on-site hourly measurements of turbulence intensity, vertical temperature difference, horizontal wind shear, and wind profile exponents.

- **Complex Terrain Diffusion Model (CTDMPLUS)** This model is a refined air quality model that is preferred for use in all stability conditions for complex terrain applications. CTDMPLUS is applicable to all receptors on terrain elevations greater than stack top height. However, the model contains no algorithms for simulating building downwash or the mixing or recirculation found in cavity zones in the lee of a hill.

- **CALPUFF** This model is a multi-layer, multi-species, non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF can use the three-dimensional meteorological fields developed by the CALMET model, or simple, single-station winds in a format consistent with the meteorological files used to derive ISCST3 steady-state Gaussian models.

5.3 Advanced Models

In some cases the particular circumstances of topography, climate, source configuration, emissions characteristics, sensitivity of receptors, local concerns, or other unusual features will require the selection of the model better suited to the situation. Regulatory models may need to be modified to reflect these unique conditions; these modifications will be accepted if they can demonstrate that they perform better than the recommended model when tested against the available air quality data. Model selection and the level of assessment to be performed can be verified by contacting AENV.

Any modification to a recommended model or any other generally available dispersion model must be supported by at least one of the following:

- a detailed observational study (field, wind tunnel, or water channel),
- theory supported by comparisons in literature,
- theory supported by comparison with on-site data.

All modified models must be shown to perform better than the regulatory model when tested against site-specific ambient monitoring data. Performance against the refined model must also be documented.

for comment only

In general, a performance evaluation consists of the following (U.S. EPA, 1992a):

- accuracy of peak predicted concentrations (against site-specific air quality data),
- a correlation analysis,
- test of model precision, and
- test of model bias.

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6 OBTAINING MODELS AND RESOURCES

This section contains instructions for accessing information relevant to dispersion modelling. There are two areas of information, the Alberta Environment web page, and the United States Environmental Protection Agency (U.S. EPA) web page. The Alberta Environment home page contains general information about AENV, Alberta regulatory information, regional meteorological data sets, and updates of these model guidelines. The U.S. EPA home page has a link to its Support Centre for Regulatory Air Models (SCRAM) page.

Whenever using these dispersion models, it is the responsibility of the user to ensure that they are running the current version of the model. This is easily checked by comparing the Julian date on the model output (example "version dated 92245") with the date given in the *Listing of Model Version Numbers* section of the SCRAM site, or by contacting AENV. The use of methods and models other than the previously mentioned regulatory models should always be confirmed with AENV before proceeding.

Most of the files are in a compressed format for faster downloading. Documents and manuals are usually written with WordPerfect 5.1 format, and should be printed from this software for best results. They are also available in Adobe Acrobat format. This viewer software is available on the internet at no charge.

6.1 Alberta Environment Home Page

Alberta Environment has developed a home page on the internet. Browser software is necessary to view this home page. The address for this page is:

http://www.gov.ab.ca/env/air/

This home page currently contains two areas relevant to air quality, namely, the *Air* and *Protection/Enforcement* sections. The Air section contains information about air quality monitoring in the province, the Clean Air Strategic Alliance, and a section related to air quality modelling. The web address of the modelling section is:

http://www.gov.ab.ca/env/air/airqual/airmodelling.html

These guidelines and information relating to the guidelines can be found at this address. AENV has set up an e-mail list server where information on updates and new versions of the guidelines will be sent periodically. The e-mail list is free, and instructions for signing up can be found at the above site.

http://www.gov.ab.ca/env/air/airqual/metdata.html

The meteorological data sets that are ready as input into ISC3 are also linked to this web site, and can be downloaded by following the links at the address above.

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The Protection/Enforcement section contains information related to the regulatory approval process, including the EPEA and AAAQG.

6.2 U.S. EPA SCRAM Home Page

The SCRAM site covers topics related to dispersion models. The internet site can be accessed at the following address:

http://www.epa.gov/scram001/index.htm

6.3 Canadian Climate Normals

The Canadian Climate Normals are available free of charge at the following web site:

http://www.cmc.ec.gc.ca/climate/

This information can be utilized for comparison with dispersion model results for simple cases and to compare the representativeness of site data or other meteorological data for the region. If sufficient data are available, climatological wind directions, wind speeds, and temperatures can be analyzed to determine the frequency of particular meteorological conditions. This could be compared to the worst-case modelled condition, to help determine possible frequencies of occurrence of elevated concentrations.

for comment only

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APPENDIX A: EXPECTED CONTENT OF SCREENING ASSESSMENTS

for comment only

1.0 Sources and Emissions

1.1 Source Data

- Number and type of sources (stack, flare, etc.)
- Plot plan
- Locations and dimensions of buildings (length, width, height)
- Design capacity (normal or average capacity may also be needed)

1.2 Characteristics of Emissions as Function of each Capacity

- Chemical composition (pollutant type) and emission rates (g/s)
- Exit (stack) height above ground (m)
- Temperature (K) or heat content (MJ/m^3 and cal/s)
- Exit velocity (m/s)
- Stack top diameter (m)
- Other parameters if not a point source

1.3 Potential Emissions during Abnormal Operations Start-Up or Shutdown

for comment only

2.0 Topography

- Description and map if necessary
- Vegetation cover/land use
- Sensitive receptors nearby (public buildings, homes, etc.)
- Location of meteorological and air quality stations

3.0 Meteorology

- Speed and direction distributions (wind roses)

4.0 Results - Dispersion Model Predictions

- Summary of background air quality if available or applicable (from air quality stations - same or other facility, or appropriate Alberta Environment station)
- Documentation of model methodology - provide justification of methods (refer to Air Quality Model Guidelines when applicable)
- Building downwash (include whether effects seen on or off facility property)
- Discussion of topographic effects with model predictions if necessary
- Predicted hourly average maximums
- Discussion of meteorology leading to highest concentration(s)
- Comparison to ambient air quality guidelines (or standards from other jurisdictions if one does not exist for pollutant)
- Comparison with existing monitoring data (if applicable)
- Copy of dispersion model output file

for comment only

APPENDIX B: EXPECTED CONTENT OF REFINED AND ADVANCED ASSESSMENTS

for comment only

1.0 Sources and Emissions

1.1 Source Data

- Number and type of sources (on-site and off-site)
- Plot plan
- Dimensions of nearby buildings
- Design, average and nominal capacity

1.2 Characteristics of Emissions as Function of Capacity

- Temperature or heat content at exit
- Exit velocity
- Exit height above ground
- Chemical composition and emission rates
- Particle sizes and amounts
- Water content
- Other parameters for non-point sources

1.3 Time Variations (Short and Long-Term)

for comment only

1.4 Potential Emissions during Abnormal Operations

- Start-up or shutdown
- Pollution control equipment failure
- Process equipment malfunction
- Damage to storage vessels
- Other accidental/unplanned emissions

1.5 Other Major Existing or Proposed Sources

2.0 Topography

- Description and map
- Elevation maxima and minima

- Vegetation cover/land use
- Sensitive receptors
- Parks, campgrounds, and wilderness areas
- Population centres and public facilities
- Location of meteorological and air quality stations

3.0 General Climatology

- Temperature
- Precipitation
- Fog
- Humidity
- Pressure
- Solar radiation
- Wind
- Severe weather (thunderstorms, tornados/dust devils, lightning, hail, icing, heavy rainfalls, heat waves, etc.)
- Cloud cover
- Synoptic patterns (air masses, fronts, surface and upper-level air flows)

for comment only

4.0 Meteorology

- Sources of data
- Representativeness of measurements (time and space)
- Topographic influences

4.1 Wind

- Speed and direction distributions (roses)
- Relation of short-term on-site to long-term off-site
- Persistence
- Diurnal and seasonal variations
- Extreme values

- Mean speed
- Prevailing and resultant winds
- Relation to visibility restrictions
- Relation to topographic effects

4.2 Temperature

- Inversion heights, strengths, frequencies, and persistence
- Mixing layer heights, diurnal and seasonal variation
- Magnitude and behaviour, diurnally and seasonally

4.3 Turbulence

- Direct measurements - frequency distributions, diurnal and seasonal variations
- Indirect determinations, definition of stability parameter (thermal/mechanical turbulence index) and description of inference scheme
- Frequency distribution, diurnal and seasonal variations

5.0 Atmospheric Dispersion (Short- and Long-Term Concentrations)

for comment only

- Summary of background air quality
- Contribution of sources to maximums, nearby and distant
- Building downwash
- Stack aerodynamic downwash
- Buoyancy momentum rise
- Topographic effects
- Model description and references
- Predicted hourly averages - magnitude, frequencies, duration, and timing
- Discussion of meteorology leading to highest concentrations
- Predicted daily averages
- Predicted annual averages
- Predicted depositions

- Comparisons to standards
- Expected odour frequencies
- Expected frequency of visibility impairment due to smoke, particulate, or condensed water vapour

6.0 Special Topics

- Risks due to uncontrolled releases
- Unusual natural phenomena
- Atmospheric chemical transformations
- Chemical reactions between plumes containing different pollutants
- Synergistic effects of multiple-component emissions
- Icing caused by water vapour emissions

7.0 Conclusion

- Summary of impact on concentrations, depositions, visibility, and odour

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